Exhibit R-2, RDT&E Budget Item Justification: PB 2017 Defense Advanced Research Projects Agency	**Date:** February 2016
Appropriation/Budget Activity 0400: *Research, Development, Test & Evaluation, Defense-Wide* / BA 3: *Advanced Technology Development (ATD)*	**R-1 Program Element (Number/Name)** PE 0603739E / *ADVANCED ELECTRONICS TECHNOLOGIES*

COST ($ in Millions)	Prior Years	FY 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total	FY 2018	FY 2019	FY 2020	FY 2021	Cost To Complete	Total Cost
Total Program Element	-	81.119	76.021	49.807	-	49.807	74.033	87.960	119.359	165.172	-	-
MT-12: *MEMS AND INTEGRATED MICROSYSTEMS TECHNOLOGY*	-	13.363	2.200	0.000	-	0.000	0.000	0.000	0.000	0.000	-	-
MT-15: *MIXED TECHNOLOGY INTEGRATION*	-	67.756	73.821	49.807	-	49.807	74.033	87.960	119.359	165.172	-	-

A. Mission Description and Budget Item Justification

The Advanced Electronics Technologies program element is budgeted in the Advanced Technology Development Budget Activity because it seeks to design and demonstrate state-of-the-art manufacturing and processing technologies for the production of various electronics and microelectronic devices, sensor systems, actuators and gear drives that have military applications and potential commercial utility. Introduction of advanced product design capability and flexible, scalable manufacturing techniques will enable the commercial sector to rapidly and cost-effectively satisfy military requirements.

The MicroElectroMechanical Systems (MEMS) and Integrated Microsystems Technology program is a broad, cross-disciplinary initiative to merge computation and power generation with sensing and actuation to realize a new technology for both perceiving and controlling weapons systems and battlefield environments. Using fabrication processes and materials similar to those used to make microelectronic devices, MEMS applies the advantages of miniaturization, multiple components and integrated microelectronics to the design and construction of integrated electromechanical and electro-chemical-mechanical systems. The MEMS program addresses issues ranging from the scaling of devices and physical forces to new organization and control strategies for distributed, high-density arrays of sensor and actuator elements. These issues include microscale power and actuation systems as well as microscale components that survive harsh environments. Thermal management technologies will develop heat resistant thermal layers to provide efficient operation for cooling electronic devices.

The Mixed Technology Integration project funds advanced development and demonstrations of selected basic and applied electronics research programs. Examples of activities funded in this project include, but are not limited to: (1) component programs that integrate mixed signal (analog and digital; photonic and electronic) or mixed substrate (Gallium Nitride, Gallium Arsenide, Indium Phosphide, or Silicon Germanium with CMOS) technology that will substantially improve the capability of existing components and/or reduce size, weight and power requirements to a level compatible with future warfighter requirements; (2) development and demonstration of brassboard system applications in such areas as laser weaponry or precision navigation and timing to address mid-term battlefield enhancements; and (3) novel technological combinations (i.e. photonics, magnetics, frequency attenuators) that could yield substantial improvement over current systems.

Exhibit R-2, RDT&E Budget Item Justification: PB 2017 Defense Advanced Research Projects Agency	Date: February 2016
Appropriation/Budget Activity 0400: *Research, Development, Test & Evaluation, Defense-Wide* / BA 3: *Advanced Technology Development (ATD)*	**R-1 Program Element (Number/Name)** PE 0603739E / *ADVANCED ELECTRONICS TECHNOLOGIES*

B. Program Change Summary ($ in Millions)	FY 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total
Previous President's Budget	92.246	79.021	87.381	-	87.381
Current President's Budget	81.119	76.021	49.807	-	49.807
Total Adjustments	-11.127	-3.000	-37.574	-	-37.574
• Congressional General Reductions	0.000	-3.000			
• Congressional Directed Reductions	0.000	0.000			
• Congressional Rescissions	0.000	0.000			
• Congressional Adds	0.000	0.000			
• Congressional Directed Transfers	0.000	0.000			
• Reprogrammings	-8.317	0.000			
• SBIR/STTR Transfer	-2.810	0.000			
• TotalOtherAdjustments	-	-	-37.574	-	-37.574

Change Summary Explanation

FY 2015: Decrease reflects reprogrammings and the SBIR/STTR transfer.
FY 2016: Decrease reflects congressional reduction.
FY 2017: Decrease reflects completion of several Endurance, Diverse & Accessible Heterogeneous Integration (DAHI), and FLASH - Scaling Fiber Arrays at Near Perfect Beam Quality program milestones.

Exhibit R-2A, RDT&E Project Justification: PB 2017 Defense Advanced Research Projects Agency		Date: February 2016
Appropriation/Budget Activity 0400 / 3	R-1 Program Element (Number/Name) PE 0603739E / *ADVANCED ELECTRONICS TECHNOLOGIES*	Project (Number/Name) MT-12 / *MEMS AND INTEGRATED MICROSYSTEMS TECHNOLOGY*

COST ($ in Millions)	Prior Years	FY 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total	FY 2018	FY 2019	FY 2020	FY 2021	Cost To Complete	Total Cost
MT-12: *MEMS AND INTEGRATED MICROSYSTEMS TECHNOLOGY*	-	13.363	2.200	0.000	-	0.000	0.000	0.000	0.000	0.000	-	-

A. Mission Description and Budget Item Justification

The MicroElectroMechanical Systems (MEMS) and Integrated Microsystems Technology project funds a broad, cross-disciplinary initiative to merge computation and power generation with sensing and actuation to realize a new technology for both perceiving and controlling weapons systems and battlefield environments. Using fabrication processes and materials similar to those used to make microelectronic devices, MEMS applies the advantages of miniaturization, multiple components and integrated microelectronics to the design and construction of integrated electromechanical and electro-chemical-mechanical systems. The MEMS program addresses issues ranging from the scaling of devices and physical forces to new organization and control strategies for distributed, high-density arrays of sensor and actuator elements. These issues include microscale precision, navigation, and timing systems as well as microscale components that survive harsh environments. These MEMS systems need to operate in a variety of thermal and vibration environments to make them tactically relevant.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2015	FY 2016	FY 2017
Title: Micro-Technology for Positioning, Navigation, and Timing (Micro PN&T)	13.363	2.200	-
Description: The Micro-Technology for Positioning, Navigation, and Timing (Micro-PNT) program is developing low-Cost, Size, Weight, and Power (CSWaP) inertial sensors and timing sources for navigation in GPS degraded environments, primarily focusing on the development of miniature solid state and atomic gyroscopes and clocks. Both classes of sensors are currently unsuitable for small platform or dismount soldier applications. Micro Electro-Mechanical Systems (MEMS) sensors have limited performance but excellent CSWaP, while atomic sensors are capable of excellent performance but are limited to laboratory experiments due to complexity and high CSWaP. Micro-PNT is advancing both technology approaches by improving the performance of MEMS inertial sensors and by miniaturizing atomic devices. Ultimately, low-CSWaP inertial sensors and clocks will enable ubiquitous guidance and navigation on all platforms, including guided munitions, unmanned aerial vehicles (micro-UAVs), and mounted and dismounted soldiers. Successful realization of Micro-PNT requires development of new microfabrication processes and novel material systems for fundamentally different sensing modalities, understanding of error sources at the micro-scale, and development of miniature inertial sensors based on atomic physics. Innovative microfabrication techniques under development will allow co-fabrication of dissimilar devices on a single chip, such that clocks, gyroscopes, accelerometers, and calibration stages can be integrated into a small, low power architecture. The program is developing miniature inertial sensors based on atomic interferometry and nuclear magnetic resonance. Ancillary research efforts for this program are funded within PE 0602716E, Project ELT-01.			

Exhibit R-2A, RDT&E Project Justification: PB 2017 Defense Advanced Research Projects Agency		**Date:** February 2016
Appropriation/Budget Activity 0400 / 3	**R-1 Program Element (Number/Name)** PE 0603739E / *ADVANCED ELECTRONICS TECHNOLOGIES*	**Project (Number/Name)** MT-12 / *MEMS AND INTEGRATED MICROSYSTEMS TECHNOLOGY*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2015	FY 2016	FY 2017
FY 2015 Accomplishments: - Fabricated low loss shell resonators for gyroscope applications with ring down time > 100 seconds. - Demonstrated a miniature, self-contained atomic gyroscope with Angle Random Walk (ARW) < 0.05 degrees/sqrt(hr) and bias stability < 0.01 degrees/hr. - Demonstrated self-calibrating MEMS gyroscope with long-term scale factor and bias of < 10 parts per million (ppm) of full scale range. - Demonstrated inertial sensing in both cold-atom and thermal atomic beam atom interferometers. - Demonstrated operation of a MEMS tuning fork gyroscope (TFG) on integrated rotation/calibration stage. ***FY 2016 Plans:*** - Demonstrate a self-contained nuclear magnetic resonance gyroscope with ARW < 5e-4deg/rt(hr) and bias stability <1e-4deg/hr in a 20cc package. - Demonstrate an atom interferometer gyroscope with ARW < 5e-4deg/rt(hr) and bias stability <1e-4deg/hr in <150cc (approximately smartphone sized). - Demonstrate whole angle operation in a 3D microgyroscope. - Demonstrate tactical-grade performance of a single-chip MEMS inertial measurement unit.			
Accomplishments/Planned Programs Subtotals	13.363	2.200	-

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

Specific programmatic performance metrics are listed above in the program accomplishments and plans section.

Exhibit R-3, RDT&E Project Cost Analysis: PB 2017 Defense Advanced Research Projects Agency | **Date:** February 2016

Appropriation/Budget Activity
0400 / 3

R-1 Program Element (Number/Name)
PE 0603739E / *ADVANCED ELECTRONICS TECHNOLOGIES*

Project (Number/Name)
MT-12 / *MEMS AND INTEGRATED MICROSYSTEMS TECHNOLOGY*

Product Development ($ in Millions)

Cost Category Item	Contract Method & Type	Performing Activity & Location	Prior Years	FY 2015 Cost	FY 2015 Award Date	FY 2016 Cost	FY 2016 Award Date	FY 2017 Base Cost	FY 2017 Base Award Date	FY 2017 OCO Cost	FY 2017 OCO Award Date	FY 2017 Total Cost	Cost To Complete	Total Cost	Target Value of Contract
Micro-Technology for Positioning, Navigation, and Timing (Micro PN&T)	C/Various	Various : Various	-	12.160		2.002		0.000		-		0.000	0	14.162	0
Subtotal			-	12.160		2.002		0.000		-		0.000	0.000	14.162	0.000

Support ($ in Millions)

Cost Category Item	Contract Method & Type	Performing Activity & Location	Prior Years	FY 2015 Cost	FY 2015 Award Date	FY 2016 Cost	FY 2016 Award Date	FY 2017 Base Cost	FY 2017 Base Award Date	FY 2017 OCO Cost	FY 2017 OCO Award Date	FY 2017 Total Cost	Cost To Complete	Total Cost	Target Value of Contract
Government Support	MIPR	Various : Various	-	0.535		0.088		0.000		-		0.000	0	0.623	0
Subtotal			-	0.535		0.088		0.000		-		0.000	0.000	0.623	0.000

Management Services ($ in Millions)

Cost Category Item	Contract Method & Type	Performing Activity & Location	Prior Years	FY 2015 Cost	FY 2015 Award Date	FY 2016 Cost	FY 2016 Award Date	FY 2017 Base Cost	FY 2017 Base Award Date	FY 2017 OCO Cost	FY 2017 OCO Award Date	FY 2017 Total Cost	Cost To Complete	Total Cost	Target Value of Contract
Management Support	C/Various	Various : Various	-	0.668		0.110		0.000		-		0.000	0	0.778	0
Subtotal			-	0.668		0.110		0.000		-		0.000	0.000	0.778	0.000

	Prior Years	FY 2015		FY 2016		FY 2017 Base		FY 2017 OCO		FY 2017 Total	Cost To Complete	Total Cost	Target Value of Contract
Project Cost Totals	-	13.363		2.200		0.000		-		0.000	0.000	15.563	0.000

Remarks

Exhibit R-4, RDT&E Schedule Profile: PB 2017 Defense Advanced Research Projects Agency		**Date:** February 2016
Appropriation/Budget Activity 0400 / 3	**R-1 Program Element (Number/Name)** PE 0603739E / *ADVANCED ELECTRONICS TECHNOLOGIES*	**Project (Number/Name)** MT-12 / *MEMS AND INTEGRATED MICROSYSTEMS TECHNOLOGY*

	FY 2015				FY 2016				FY 2017				FY 2018				FY 2019				FY 2020				FY 2021			
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Micro-Technology for Positioning, Navigation, and Timing (Micro PN&T)																												
Whole angle 3D microgyroscope demonstration																												
Chip-scale combinatorial atomic navigator (C-SCAN) integrated atomic gyroscope demonstration																												
C-SCAN atomic gyroscope government evaluation																												

Exhibit R-4A, RDT&E Schedule Details: PB 2017 Defense Advanced Research Projects Agency		**Date:** February 2016
Appropriation/Budget Activity 0400 / 3	**R-1 Program Element (Number/Name)** PE 0603739E / *ADVANCED ELECTRONICS TECHNOLOGIES*	**Project (Number/Name)** MT-12 / *MEMS AND INTEGRATED MICROSYSTEMS TECHNOLOGY*

Schedule Details

	Start		End	
Events by Sub Project	**Quarter**	**Year**	**Quarter**	**Year**
Micro-Technology for Positioning, Navigation, and Timing (Micro PN&T)				
Whole angle 3D microgyroscope demonstration	4	2015	4	2015
Chip-scale combinatorial atomic navigator (C-SCAN) integrated atomic gyroscope demonstration	1	2016	1	2016
C-SCAN atomic gyroscope government evaluation	3	2016	4	2016

Exhibit R-2A, RDT&E Project Justification: PB 2017 Defense Advanced Research Projects Agency			Date: February 2016
Appropriation/Budget Activity 0400 / 3	**R-1 Program Element (Number/Name)** PE 0603739E / *ADVANCED ELECTRONICS TECHNOLOGIES*	**Project (Number/Name)** MT-15 / *MIXED TECHNOLOGY INTEGRATION*	

COST ($ in Millions)	Prior Years	FY 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total	FY 2018	FY 2019	FY 2020	FY 2021	Cost To Complete	Total Cost
MT-15: *MIXED TECHNOLOGY INTEGRATION*	-	67.756	73.821	49.807	-	49.807	74.033	87.960	119.359	165.172	-	-

A. Mission Description and Budget Item Justification

The Mixed Technology Integration project funds advanced development and demonstrations of selected basic and applied electronics research programs. Examples of activities funded in this project include, but are not limited to: (1) component programs that integrate mixed signal (analog and digital; photonic and electronic) or mixed substrate (Gallium Nitride, Gallium Arsenide, Indium Phosphide, or Silicon Germanium with CMOS) technology that will substantially improve the capability of existing components and/or reduce size, weight and power requirements to a level compatible with future warfighter requirements; (2) development and demonstration of brassboard system applications in such areas as laser weaponry or precision navigation and timing to address mid-term battlefield enhancements; and (3) novel technological combinations (i.e., photonics, magnetics, frequency attenuators) that could yield substantial improvement over current systems.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2015	FY 2016	FY 2017
Title: Endurance	37.669	23.473	15.307

Description: The Endurance program will develop technology for pod- or internally-mounted lasers to protect a variety of airborne platforms from emerging and legacy electro-optical IR guided surface-to-air missiles. The Endurance system will be a completely self-contained laser weapon system brassboard in an open architecture configuration.

The focus of the Endurance effort under MT-15 will be to develop and test integrated subsystems, such as a laser subsystem, a command subsystem, a threat missile warning subsystem, a target acquisition and tracking subsystem, a beam control and director subsystem, an energy storage and electrical power delivery subsystem, a thermal management subsystem a mechanical support framework, subsystem interfaces, and the design, integration, and testing of a form/fit/function brassboard laser countermeasure. This program is an early application of technology developed in the Excalibur program and will transition via industry. Applied research for this program is budgeted in PE 0602702E, Project TT-06.

FY 2015 Accomplishments:
- Acquired threat devices and/or surrogates in preparation for live fire testing.
- Completed the critical design for subsystem integration.
- Acquired components for the fabrication of subsystems.

FY 2016 Plans:
- Complete fabrication and test subsystems.
- Integrate, assemble and bench-test the brassboard system.

Exhibit R-2A, RDT&E Project Justification: PB 2017 Defense Advanced Research Projects Agency		**Date:** February 2016
Appropriation/Budget Activity 0400 / 3	**R-1 Program Element (Number/Name)** PE 0603739E / *ADVANCED ELECTRONICS TECHNOLOGIES*	**Project (Number/Name)** MT-15 / *MIXED TECHNOLOGY INTEGRATION*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2015	FY 2016	FY 2017
- Obtain necessary range approvals for live-fire testing. ***FY 2017 Plans:*** - Test the brassboard laser weapon system at outdoor test ranges against a representative set of static and live-fire threat targets. - Assess brassboard system performance in live-fire testing. - Develop a preliminary engineering design for a flight-prototype of a pod-mounted laser weapon system.			
Title: Diverse & Accessible Heterogeneous Integration (DAHI) ***Description:*** The scaling of silicon (Si) transistors to ever smaller dimensions has led to dramatic gains in processor performance over the past fifty years. In parallel, integrated circuit (IC) designers for radio frequency (RF) circuits have leveraged the different material properties of compound semiconductor (CS) technologies such as indium phosphide (InP), gallium arsenide (GaAs), gallium nitride (GaN) and silicon-germanium (SiGe) to enable devices that operate at frequencies and powers difficult or impossible to achieve in Silicon. Historically, a designer would have to decide between the high density of Si circuits or the high performance of CS materials. Prior DARPA efforts have demonstrated the ability to achieve near-ideal "mix-and-match" capability for DoD circuit designers with limited demonstrations of the heterogeneous integration of silicon and InP technologies that far exceeded what can be accomplished with one technology alone. Specifically, the Compound Semiconductor Materials On Silicon (COSMOS) program enabled transistors of InP to be freely mixed with silicon complementary metal-oxide semiconductor (CMOS) circuits to obtain the benefits of both technologies (very high speed and very high circuit complexity/density, respectively). The Diverse & Accessible Heterogeneous Integration (DAHI) effort will take this capability to the next level, ultimately offering the seamless co-integration of a variety of semiconductor devices (for example, GaN, InP, GaAs, antimonide based Compound Semiconductors), microelectromechanical (MEMS) sensors and actuators, photonic devices (e.g., lasers, photo-detectors) and thermal management structures. This capability will revolutionize our ability to build true "systems on a chip" (SoCs) and allow dramatic size, weight and volume reductions while enabling higher performance such as power, bandwidth or dynamic range in our electronic systems for electronic warfare, communications and radar. This program has applied research efforts funded in PE 0602716E, Project ELT-01. The Advanced Technology Development part of this program will leverage these complementary efforts to focus on the establishment of an accessible, manufacturable technology for device-level heterogeneous integration of a wide array of materials and devices (including, for example, multiple electronics and MEMS technologies) with complex silicon-enabled (e.g. CMOS) architectures on a common silicon substrate platform. This part of the program is expected to culminate in accessible foundry processes of DAHI technology and demonstrations of advanced microsystems with innovative architectures and designs that leverage heterogeneous integration. By the end of the program, this effort seeks to establish a technologically mature, sustainable DAHI foundry service to be made available (with appropriate computer-aided design support) to a wide variety of DoD laboratory, Federally Funded Research and Development Center (FFRDC), academic and industrial designers.	15.496	15.335	6.000

Exhibit R-2A, RDT&E Project Justification: PB 2017 Defense Advanced Research Projects Agency		Date: February 2016
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B. Accomplishments/Planned Programs ($ in Millions)	**FY 2015**	**FY 2016**	**FY 2017**
FY 2015 Accomplishments: - Developed a high-yield, high-reliability accessible manufacturing process flow which will be transitioned to a self-sustaining foundry activity providing heterogeneously integrated circuits with four materials/device technologies (silicon (Si) CMOS, InP heterojunction bipolar transistors (HBTs), GaN high-electron-mobility transistors (HEMTs), and high-Q passive devices). - Demonstrated heterogeneously integrated yield test circuits using three device technologies (Si CMOS, InP HBTs, and GaN HEMTs) with measured reliability data. Tracked fabrication process issues and risks and systematically mitigated or eliminated them, resulting in yield structures which meet program metrics. - Demonstrated capability for supporting multi-project wafer runs using the heterogeneous foundry service under development. - Demonstrated a multi-project wafer run including eight external design teams using the DAHI process. Facilitated multi-project wafer foundry through development and support of process design kit and thermal simulation tools. ***FY 2016 Plans:*** - Complete development of a high-yield, high-reliability accessible manufacturing process flow which will be transitioned to a self-sustaining foundry activity providing heterogeneously integrated circuits with four materials/device technologies (Si CMOS, InP HBTs, GaN HEMTs, and high-Q passive devices). - Complete demonstration of capability for supporting multi-project wafer runs using the heterogeneous foundry service under development. ***FY 2017 Plans:*** - Complete development of a high-yield, high-reliability accessible manufacturing process flow which will be transitioned to a self-sustaining foundry activity providing heterogeneously integrated circuits with four materials/device technologies (Si CMOS, InP HBTs, GaN HEMTs, and high-Q passive devices). Finalize refinements of yield and reliability, and coordinate with self-sustaining foundry activity to ensure successful transition of heterogeneous integration technology. - Complete demonstration of capability for supporting multi-project wafer runs using the heterogeneous foundry service under development. Finalize the development of seamless process design kits and integrated design flows to facilitate the use of the foundry service by external users.			
Title: FLASH - Scaling Fiber Arrays at Near Perfect Beam Quality ***Description:*** The goal of the FLASH program is to demonstrate a transportable, ultra-low size, weight, and power (SWaP), packaged laser system by coherently combining the outputs of an array of ultra-lightweight, flight-worthy high-power fiber lasers. The packaged FLASH laser system will project a >30-kW-class beam with near perfect beam quality and very high electrical-to-optical efficiency. The SWaP will be consistent with weight and volume densities needed to support the integration of laser weapons on a broad range of military platforms, including 4th and 5th generation aircraft and UAVs. To accomplish these objectives, FLASH will: (1) greatly reduce the overall size and weight of packaged coherently-combinable high-power fiber laser amplifiers while greatly simplifying the demands they make on support systems such as cabling, cooling lines and	12.591	15.813	12.500

Exhibit R-2A, RDT&E Project Justification: PB 2017 Defense Advanced Research Projects Agency		Date: February 2016
Appropriation/Budget Activity 0400 / 3	**R-1 Program Element (Number/Name)** PE 0603739E / *ADVANCED ELECTRONICS TECHNOLOGIES*	**Project (Number/Name)** MT-15 / *MIXED TECHNOLOGY INTEGRATION*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2015	FY 2016	FY 2017
support structures while increasing their efficiency and resistance to shock, vibration and acoustics; and (2) fabricate an array of these ultralight fiber-laser amplifiers and integrate them with advanced battery power, thermal management and coherent-beam combination sub-systems into a transportable, fully packaged, ultra-low SWaP laser system. ***FY 2015 Accomplishments:*** - Developed and tested a packaged, flight-worthy, coherently-combinable, fiber laser amplifier with an output power, beam-quality, size and weight consistent with system integration on tactical aircraft. - Developed a preliminary design for a >30 kW transportable, packaged laser system including fiber lasers, thermal management, power systems, and beam combination. - Demonstrated, on a lab bench, the coherent combination of over 100 low power fiber lasers into a single beam as a proof-of-concept for the high power system. - Demonstrated, on a lab bench, the coherent combination of 42 output beams of kW-class fiber lasers into a single beam with high efficiency and near-perfect beam quality. ***FY 2016 Plans:*** - Develop a critical design for a >30 kW transportable, packaged laser system. - Fabricate and/or procure parts and hardware for the >30 kW transportable, packaged laser system. - Assemble and test key subsystems for the >30 kW transportable, packaged laser system. - Begin the integration of key subsystems for a >30 kW transportable, packaged laser system. ***FY 2017 Plans:*** - Complete integration of the >30 kW transportable, packaged laser system. - Test and demonstrate the >30 kW transportable, packaged laser system.			
Title: Common Heterogeneous integration & IP reuse Strategies (CHIPS)* ***Description:*** *Formerly Fast and Big Mixed-Signal Designs (FAB) Developing capabilities to intermix and tightly integrate silicon processes which are currently supported at different scaling nodes and by different vendors is critical to increasing the capabilities of high-performance military microelectronics. For example, Silicon-Germanium (SiGe) Bipolar Complementary Metal-oxide Semiconductor (BiCMOS) processes allow CMOS logic to be integrated with radio frequency (RF) heterojunction bipolar transistors (HBTs), which enables mixed-signal circuits having RF analog capabilities tightly coupled to digital processing. However, the SiGe process flow was developed to integrate to a single CMOS technology node and significant design and engineering effort is required to retarget the flow for a new node. Thus, BiCMOS processes tend to lag behind commercial CMOS by several generations. CHIPS will investigate the potential for a truly process-agnostic integration technology, i.e., one that is inclusive of any current or future circuit fabrication technology such as	-	4.200	5.500

Exhibit R-2A, RDT&E Project Justification: PB 2017 Defense Advanced Research Projects Agency		Date: February 2016
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B. Accomplishments/Planned Programs ($ in Millions)	FY 2015	FY 2016	FY 2017
Gallium Arsenide (GaAs), Gallium Nitride (GaN) and SiGe with a standardized interconnect topology. Such a technology platform will enable the design of individual circuit Intellectual Property (IP) blocks, such as low-noise amplifiers and analog-to-digital converters, with a goal of re-use of the IP across applications. Re-use will allow the DoD to amortize the upfront design cost of these blocks over several designs instead of leveling the burden on a single program. Furthermore, the IP can be designed in the fabrication process best suited for the performance goals and evolve more quickly than larger, more expensive single chip systems-on-a-chip. Through standardization of the interface, CHIPS will enable the DoD to leverage the advancements driven by the global semiconductor market rather than relying on a single on-shore foundry provider or on proprietary circuit designs owned by a handful of traditional prime performers. In the Advanced Technology Development part of this program, focus will be placed on the development of rapid development and insertion of microsystems utilizing III-V semiconductors and other microelectronic technologies with advanced Si CMOS. This program has Applied Research efforts funded in PE 0602716E, Project ELT-01. ***FY 2016 Plans:*** - Investigate analog intellectual property (IP) reuse techniques for efficient, rapid fabrication of high-performance RF/microwave circuits. - Develop standardized, high-bandwidth interfaces for chiplet-to-chip interconnection. - Initiate circuit demonstration using intellectual property reuse techniques. ***FY 2017 Plans:*** - Conduct system demonstrations using standardized, high-bandwidth interfaces for chiplet-to-chip interconnection of heterogeneous IP. - Initiate circuit demonstrations of chip-to-chip interconnects for heterogeneous IP RF electronic chip stacks.			
Title: Precise Robust Inertial Guidance for Munitions (PRIGM) ***Description:*** The DoD relies on GPS for ubiquitous and accurate positioning, navigation, and timing (PNT). With the increased prevalence of intentional GPS jamming, spoofing, and other GPS-denial threats, GPS access is increasingly unavailable in contested theaters and alternative sources of PNT are required. In particular, guided munitions navigation is the most immediate and among the most demanding of GPS-denial challenges, due to the necessity of operating in highly contested theaters and the stringent requirements for minimization of cost, size, weight, and power consumption (CSWaP). The Precise Robust Inertial Guidance for Munitions (PRIGM) program will develop low-CSWaP inertial sensor technology for GPS-free munitions navigation. PRIGM comprises two focus areas: 1) Development of a Navigation-Grade Inertial Measurement Unit (NGIMU) that transitions state-of-the-art MEMS to DoD platforms by 2020; and 2) Research and development of Advanced Inertial MEMS Sensors (AIMS) to achieve gun-hard, high-bandwidth, high dynamic range navigation requirements with the objective of complete autonomy in 2030. PRIGM will advance state-of-the-art MEMS gyros from TRL-3 devices to a TRL-6 transition platform (complete IMU) that	-	13.000	10.500

Exhibit R-2A, RDT&E Project Justification: PB 2017 Defense Advanced Research Projects Agency		Date: February 2016
Appropriation/Budget Activity 0400 / 3	**R-1 Program Element (Number/Name)** PE 0603739E / *ADVANCED ELECTRONICS TECHNOLOGIES*	**Project (Number/Name)** MT-15 / *MIXED TECHNOLOGY INTEGRATION*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2015	FY 2016	FY 2017
enables Service Labs to perform TRL-7 field demonstrations. PRIGM will exploit recent advances in heterogeneous integration of photonics and CMOS and advanced MEMS technology to realize novel inertial sensors for application in extreme dynamic environments and beyond navigation-grade performance. At present, DoD suffers a trade-space dichotomy between low-CSWaP tactical-grade IMUs, based on MEMS inertial sensors, and relatively high-CSWaP navigation-grade IMUs, based on ring-laser or interferometric fiber-optic gyroscopes (RLG/iFOG). RLG/iFOG is the technology of choice for high-value platforms. However, for the vast majority of platforms (munitions, dismounts, UAVs), CSWaP necessitates the use of lower-performance, MEMS-based IMUs. Under the micro-PNT program, DARPA has developed MEMS gyroscopes with performance rivaling that of navigation-grade interferometric fiber optic gyros (IFOGs), thus exposing a new tradespace for low-CSWaP navigation grade IMUs. The ultimate goal of the program is to develop a complete MEMS-based navigation-grade IMU with an identical mechanical/electronic interface to existing DoD-standard tactical-grade MEMS IMUs, thereby providing a drop-in replacement for existing DoD systems and rapid transition through early insertion demonstrations. This program has basic research efforts funded in PE 0601101E, Project ES-01 and applied research efforts funded in PE 0602716E, Project ELT-01. ***FY 2016 Plans:*** - Initiate efforts to demonstrate MEMS inertial sensors that meet all NGIMU performance and environmental requirements. - Design, fabricate, and characterize MEMS gyroscopes meeting stability and repeatability specifications consistent with navigation-grade performance. - Design, fabricate, and characterize MEMS accelerometers meeting stability and repeatability specifications consistent with navigation-grade performance. ***FY 2017 Plans:*** - Demonstrate and deliver five MEMS gyroscopes meeting stability and repeatability specifications consistent with navigation-grade performance. - Demonstrate and deliver five MEMS accelerometers meeting stability and repeatability specifications consistent with navigation-grade performance. - Commence development of MEMS-based, navigation-grade, integrated IMU meeting program-defined SWaP and performance metrics, excluding environmental requirements and shock survival.			
Title: Direct SAMpling Digital ReceivER (DISARMER) ***Description:*** The goal of the Direct SAMpling Digital ReceivER (DISARMER) program is to produce a hybrid photonic-electronic analog-to-digital converter (ADC) capable of coherently sampling the entire X-band (8-12 GigaHertz (GHz)). Conventional	2.000	2.000	-

Exhibit R-2A, RDT&E Project Justification: PB 2017 Defense Advanced Research Projects Agency		Date: February 2016
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B. Accomplishments/Planned Programs ($ in Millions)	FY 2015	FY 2016	FY 2017
electronic wideband receivers are limited in dynamic range by both the electronic mixer and the back-end digitizers. By employing an ultra-stable optical clock, the DISARMER program will allow for mixer-less digitization and thereby improve the dynamic range 100x over the state of the art. Such a wide-bandwidth, high-fidelity receiver will have applications in electronic warfare and signals intelligence systems with the potential to drastically reduce the cost, size and weight of these systems. The DISARMER program will design, fabricate, and test a hybrid photonic-electronic ADC packaged in a standard form factor. This involves the integration of electronic and photonic circuits, packaging of a mode-locked laser with ultralow jitter, and delivering a field programmable gate array with the necessary firmware to process the sampled data. This program has applied research efforts funded in PE 0602716E, Project ELT-01. ***FY 2015 Accomplishments:*** - Designed, assembled, and tested the prototype track-and-hold chip with 8 channels and optimized optical response to minimize the parasitic capacitance of the circuit. - Demonstrated direct sampling of a 4 GHz-wide bandwidth signal at 7 effective bits of fidelity. ***FY 2016 Plans:*** - Demonstrate direct sampling of a 4 GHz-wide bandwidth signal at 10 effective bits of fidelity. - Test system performance across both baseband and the entire X-band (8-12 GHz).			
Accomplishments/Planned Programs Subtotals	67.756	73.821	49.807

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

Specific programmatic performance metrics are listed above in the program accomplishments and plans section.

Exhibit R-3, RDT&E Project Cost Analysis: PB 2017 Defense Advanced Research Projects Agency		**Date:** February 2016
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Product Development ($ in Millions)

				FY 2015		FY 2016		FY 2017 Base		FY 2017 OCO		FY 2017 Total			
Cost Category Item	**Contract Method & Type**	**Performing Activity & Location**	**Prior Years**	**Cost**	**Award Date**	**Cost**	**Award Date**	**Cost**	**Award Date**	**Cost**	**Award Date**	**Cost**	**Cost To Complete**	**Total Cost**	**Target Value of Contract**
Endurance	C/CPFF	NorthropGrumman : CA	-	18.920	Sep 2015	10.742		7.063		-		7.063	Continuing	Continuing	Continuing
Endurance	C/Various	Various : Various	-	12.932		8.534		3.652		-		3.652	Continuing	Continuing	Continuing
Diverse & Accessible Heterogeneous Integration (DAHI)	C/CPFF	NorthropGrumman : CA	-	11.004	May 2015	5.910		0.000		-		0.000	Continuing	Continuing	Continuing
Diverse & Accessible Heterogeneous Integration (DAHI)	C/Various	Various : Various	-	3.097		8.045		5.185		-		5.185	Continuing	Continuing	Continuing
FLASH - Scaling Fiber Arrays at Near Perfect Beam Quality	C/Various	Various : Various	-	11.568		14.280		11.375		-		11.375	Continuing	Continuing	Continuing
Direct SAMpling Digital ReceivER (DISARMER)	C/Various	Various : Various	-	1.820		1.820		0.000		-		0.000	Continuing	Continuing	Continuing
Common Heterogeneous integration & IP reuse Strategies (CHIPS)	C/TBD	Various : Various	-	0.000		3.672		4.755		-		4.755	Continuing	Continuing	Continuing
Precise Robust Inertial Guidance for Munitions (PRIGM)	C/TBD	Various : Various	-	0.000		11.830		9.555		-		9.555	Continuing	Continuing	Continuing
		Subtotal	-	59.341		64.833		41.585		-		41.585	-	-	-

Support ($ in Millions)

				FY 2015		FY 2016		FY 2017 Base		FY 2017 OCO		FY 2017 Total			
Cost Category Item	**Contract Method & Type**	**Performing Activity & Location**	**Prior Years**	**Cost**	**Award Date**	**Cost**	**Award Date**	**Cost**	**Award Date**	**Cost**	**Award Date**	**Cost**	**Cost To Complete**	**Total Cost**	**Target Value of Contract**
Government Support	MIPR	Various : Various	-	2.655		3.083		2.242		-		2.242	Continuing	Continuing	Continuing
		Subtotal	-	2.655		3.083		2.242		-		2.242	-	-	-

Exhibit R-3, RDT&E Project Cost Analysis: PB 2017 Defense Advanced Research Projects Agency		**Date:** February 2016
Appropriation/Budget Activity 0400 / 3	**R-1 Program Element (Number/Name)** PE 0603739E / *ADVANCED ELECTRONICS TECHNOLOGIES*	**Project (Number/Name)** MT-15 / *MIXED TECHNOLOGY INTEGRATION*

Test and Evaluation ($ in Millions)

Cost Category Item	Contract Method & Type	Performing Activity & Location	Prior Years	FY 2015 Cost	FY 2015 Award Date	FY 2016 Cost	FY 2016 Award Date	FY 2017 Base Cost	FY 2017 Base Award Date	FY 2017 OCO Cost	FY 2017 OCO Award Date	FY 2017 Total Cost	Cost To Complete	Total Cost	Target Value of Contract
Endurance Testing	C/Various	Various : Various	-	2.427		2.084		3.214		-		3.214	Continuing	Continuing	Continuing
		Subtotal	-	2.427		2.084		3.214		-		3.214	-	-	-

Management Services ($ in Millions)

Cost Category Item	Contract Method & Type	Performing Activity & Location	Prior Years	FY 2015 Cost	FY 2015 Award Date	FY 2016 Cost	FY 2016 Award Date	FY 2017 Base Cost	FY 2017 Base Award Date	FY 2017 OCO Cost	FY 2017 OCO Award Date	FY 2017 Total Cost	Cost To Complete	Total Cost	Target Value of Contract
Management Support	C/Various	Various : Various	-	3.333		3.821		2.766		-		2.766	Continuing	Continuing	Continuing
		Subtotal	-	3.333		3.821		2.766		-		2.766	-	-	-

	Prior Years	FY 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total	Cost To Complete	Total Cost	Target Value of Contract
Project Cost Totals	-	67.756	73.821	49.807	-	49.807	-	-	-

Remarks

Exhibit R-4, RDT&E Schedule Profile: PB 2017 Defense Advanced Research Projects Agency		**Date:** February 2016
Appropriation/Budget Activity 0400 / 3	**R-1 Program Element (Number/Name)** PE 0603739E / *ADVANCED ELECTRONICS TECHNOLOGIES*	**Project (Number/Name)** MT-15 / *MIXED TECHNOLOGY INTEGRATION*

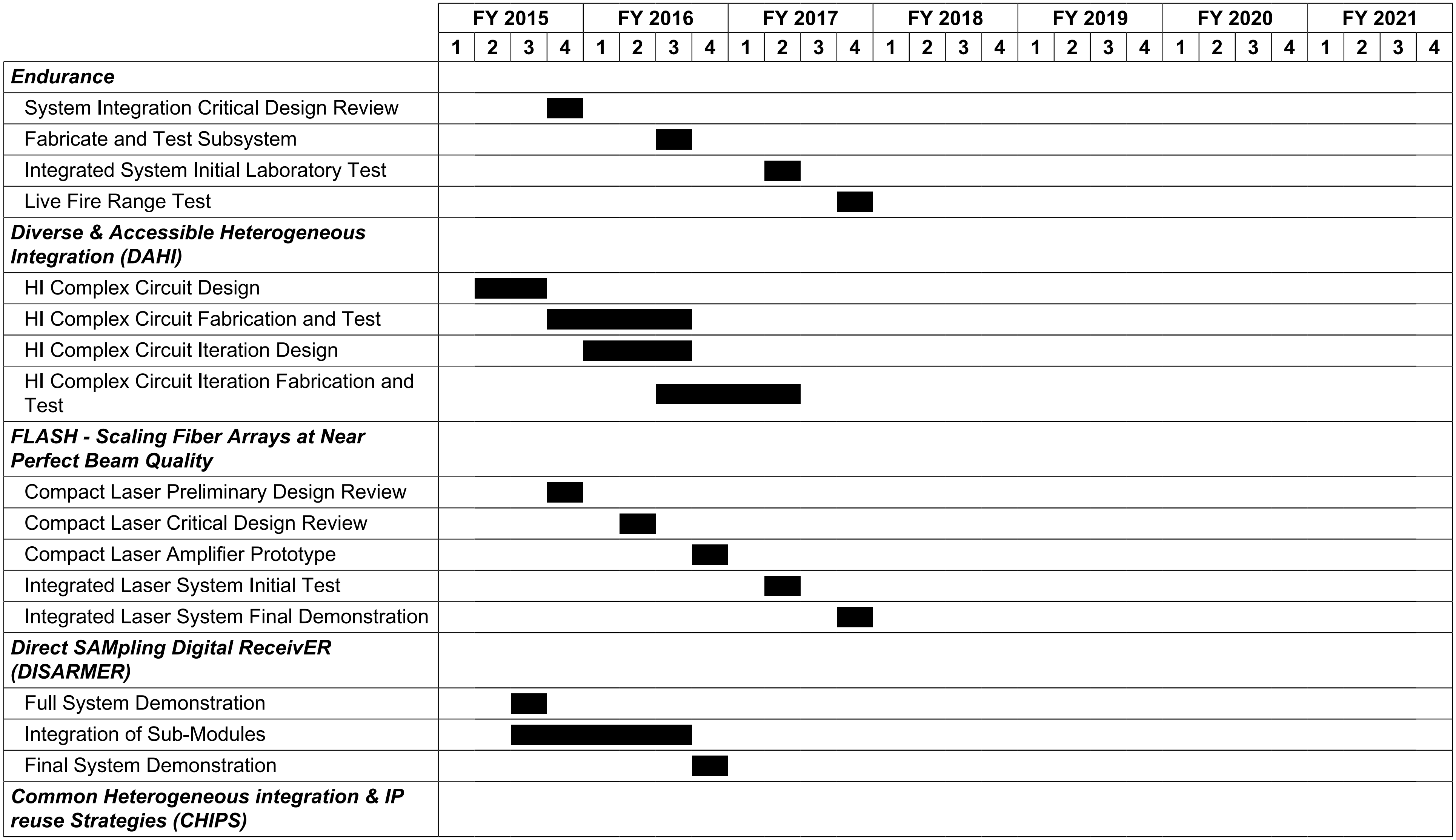

Exhibit R-4, RDT&E Schedule Profile: PB 2017 Defense Advanced Research Projects Agency		Date: February 2016
Appropriation/Budget Activity 0400 / 3	**R-1 Program Element (Number/Name)** PE 0603739E / *ADVANCED ELECTRONICS TECHNOLOGIES*	**Project (Number/Name)** MT-15 / *MIXED TECHNOLOGY INTEGRATION*

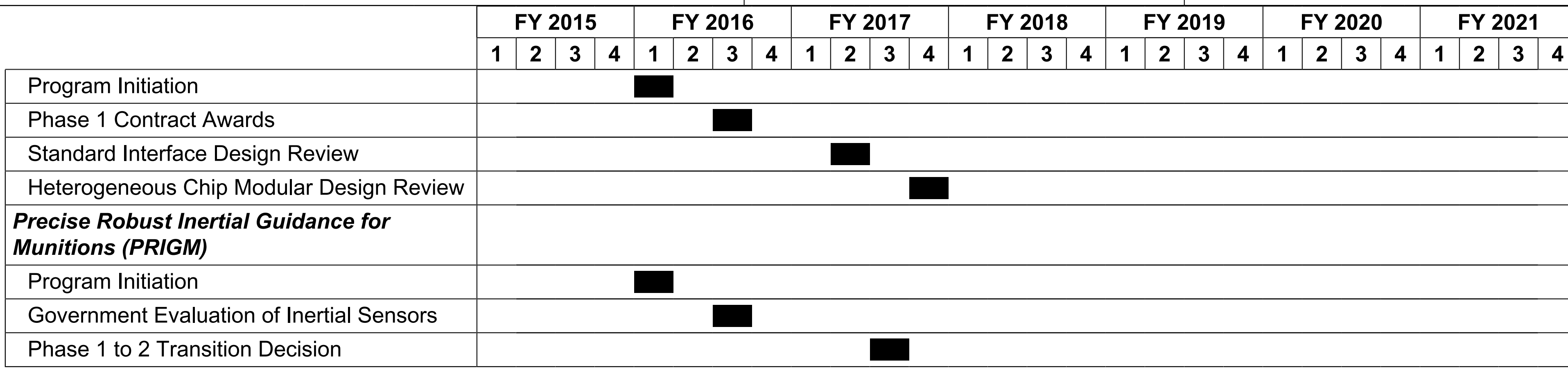

Exhibit R-4A, RDT&E Schedule Details: PB 2017 Defense Advanced Research Projects Agency		Date: February 2016
Appropriation/Budget Activity 0400 / 3	**R-1 Program Element (Number/Name)** PE 0603739E / *ADVANCED ELECTRONICS TECHNOLOGIES*	**Project (Number/Name)** MT-15 / *MIXED TECHNOLOGY INTEGRATION*

Schedule Details

	Start		End	
Events by Sub Project	**Quarter**	**Year**	**Quarter**	**Year**
Endurance				
System Integration Critical Design Review	4	2015	4	2015
Fabricate and Test Subsystem	3	2016	3	2016
Integrated System Initial Laboratory Test	2	2017	2	2017
Live Fire Range Test	4	2017	4	2017
Diverse & Accessible Heterogeneous Integration (DAHI)				
HI Complex Circuit Design	2	2015	3	2015
HI Complex Circuit Fabrication and Test	4	2015	3	2016
HI Complex Circuit Iteration Design	1	2016	3	2016
HI Complex Circuit Iteration Fabrication and Test	3	2016	2	2017
FLASH - Scaling Fiber Arrays at Near Perfect Beam Quality				
Compact Laser Preliminary Design Review	4	2015	4	2015
Compact Laser Critical Design Review	2	2016	2	2016
Compact Laser Amplifier Prototype	4	2016	4	2016
Integrated Laser System Initial Test	2	2017	2	2017
Integrated Laser System Final Demonstration	4	2017	4	2017
Direct SAMpling Digital ReceivER (DISARMER)				
Full System Demonstration	3	2015	3	2015
Integration of Sub-Modules	3	2015	3	2016
Final System Demonstration	4	2016	4	2016
Common Heterogeneous integration & IP reuse Strategies (CHIPS)				
Program Initiation	1	2016	1	2016

Exhibit R-4A, RDT&E Schedule Details: PB 2017 Defense Advanced Research Projects Agency		**Date:** February 2016
Appropriation/Budget Activity 0400 / 3	**R-1 Program Element (Number/Name)** PE 0603739E / *ADVANCED ELECTRONICS TECHNOLOGIES*	**Project (Number/Name)** MT-15 / *MIXED TECHNOLOGY INTEGRATION*

	Start		End	
Events by Sub Project	**Quarter**	**Year**	**Quarter**	**Year**
Phase 1 Contract Awards	3	2016	3	2016
Standard Interface Design Review	2	2017	2	2017
Heterogeneous Chip Modular Design Review	4	2017	4	2017
Precise Robust Inertial Guidance for Munitions (PRIGM)				
Program Initiation	1	2016	1	2016
Government Evaluation of Inertial Sensors	3	2016	3	2016
Phase 1 to 2 Transition Decision	3	2017	3	2017